

# Exoplanet Exploration Program

**Astrometry: Ground-based and  
Smaller Space Missions**  
*Exoplanet Forum 2008*  
*Pasadena*

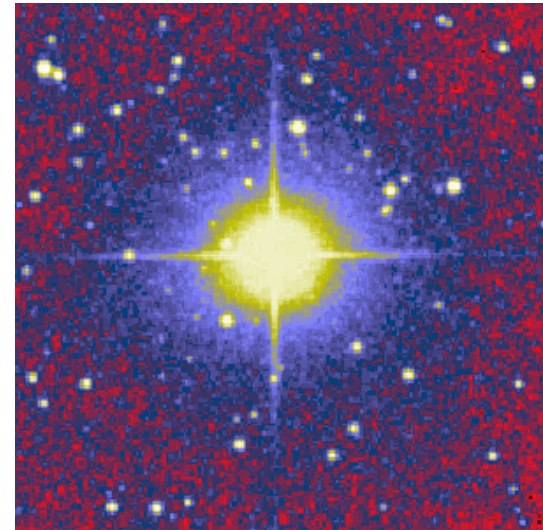
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**May 28, 2008**

# ***Astrometry: Ground-based 1***

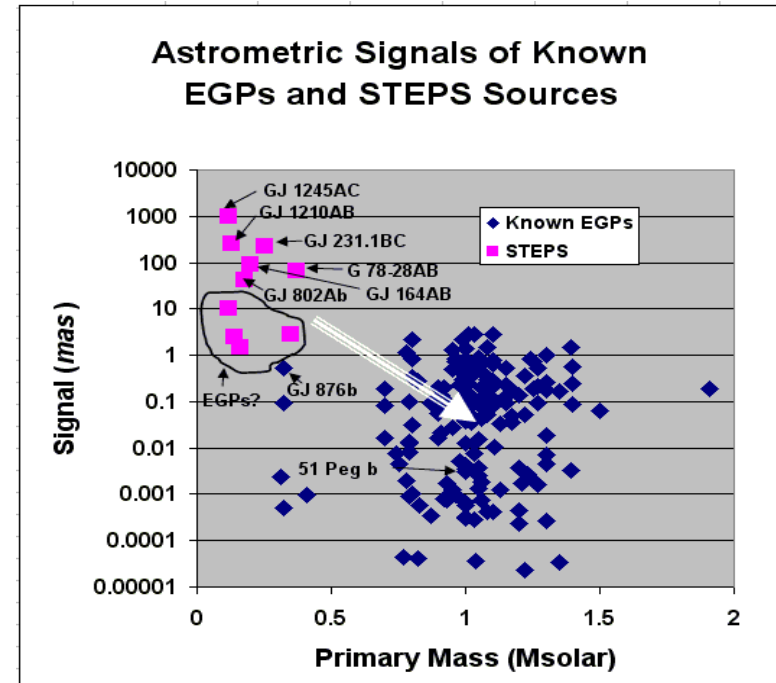
- ***Why?***
  - Add significantly to the number of planets around low-mass stars (currently ~10)
  - Develop a high dynamic-range imager (HDR) to measure astrometric motion of bright targets and much dimmer reference stars



**This is HD 38529, a solar-like star with two known planets. With a HDR imager we would make the first astrometric measurement of the planetary mass (DSS).**

# Astrometry: Ground-based 2

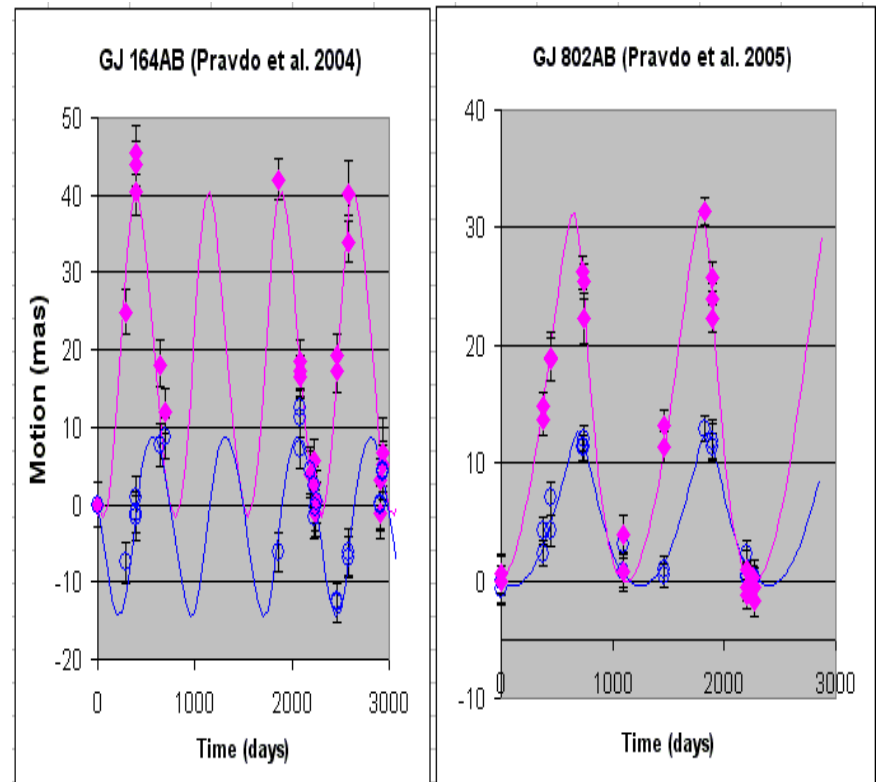
- Measure dynamical masses w/o inclination angle ambiguity



The astrometric signals of the extrasolar planets (dark diamonds) and the STEPS discoveries (light squares).

# Astrometry: Ground-based 3

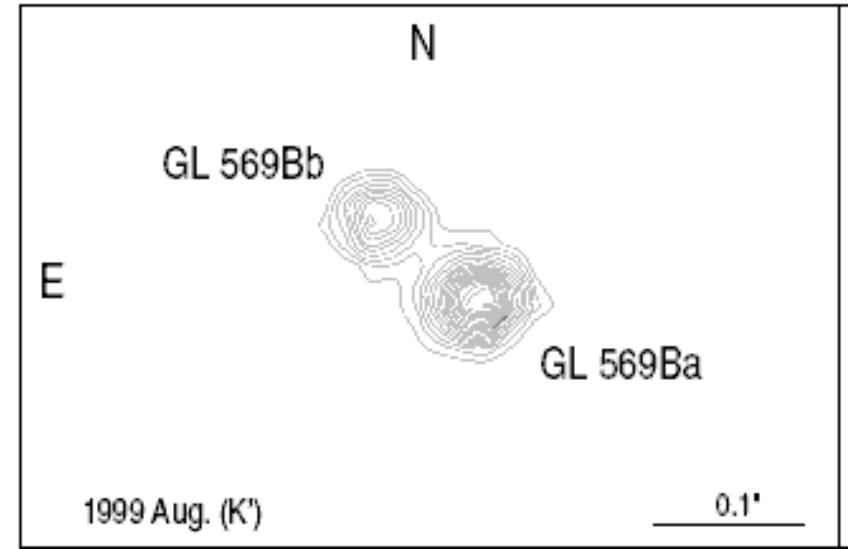
- Optical narrow-angle
- Current programs
  - STEPS (Pravdo, Shaklan, northern sky, BDs)
  - RECONS (Henry, southern sky, companions)
  - CAPS (Boss, southern sky, new sensor)
- Sub-*mas* precision
- To discover planets
  - Large apertures ( $\geq 2.5$ -m, for increased efficiency)
  - Increased observing time allocation (e.g. 10% of RV time)
  - Funding for enhanced instruments: high dynamic range (HDR) detector, IR



**The astrometric motion of two M dwarfs with BD companions discovered with STEPS. (STEPS RA data-red diamonds, Decl. data-blue circles, and models-curves).**

# Astrometry: Ground-based 4

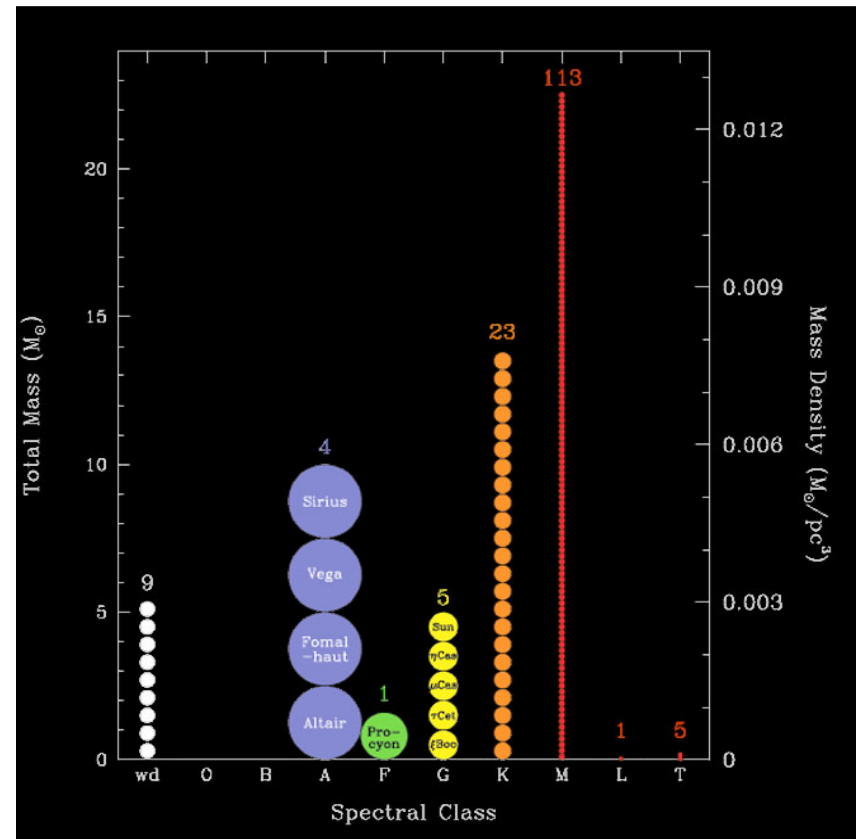
- Adaptive optics imaging
  - Currently with contrast ratios of  $\leq 100$ , perhaps larger in selected cases
  - Currently with separations of  $\geq 10$ s of *mas*
  - Characterize planets, but typically does not discover or measure dynamical masses
- Programs
  - Keck Interferometer
  - VLT



Lane et al. 2001

# Astrometry: Smaller Space Missions 1

- *Why?*
  - Low-mass stars needed to complete census of planets
  - Cutting edge of planet formation theory: core accretion or disk instability?



The large majority of all stars including those shown, < 8 pc away, are M dwarfs (the figure is a complete sample > 30° south latitude).

# Astrometry: Smaller Space Missions 2

- Small or medium-sized missions featuring narrow-angle astrometry
- A complementary coronagraph with a contrast ratio in the range  $10^{-4}$ - $10^{-6}$
- Infra-red detectors to target low-mass stars
- E.g., Giant Planets around M, L, T Dwarfs in the IR (GIMLI) w/1.4-m aperture

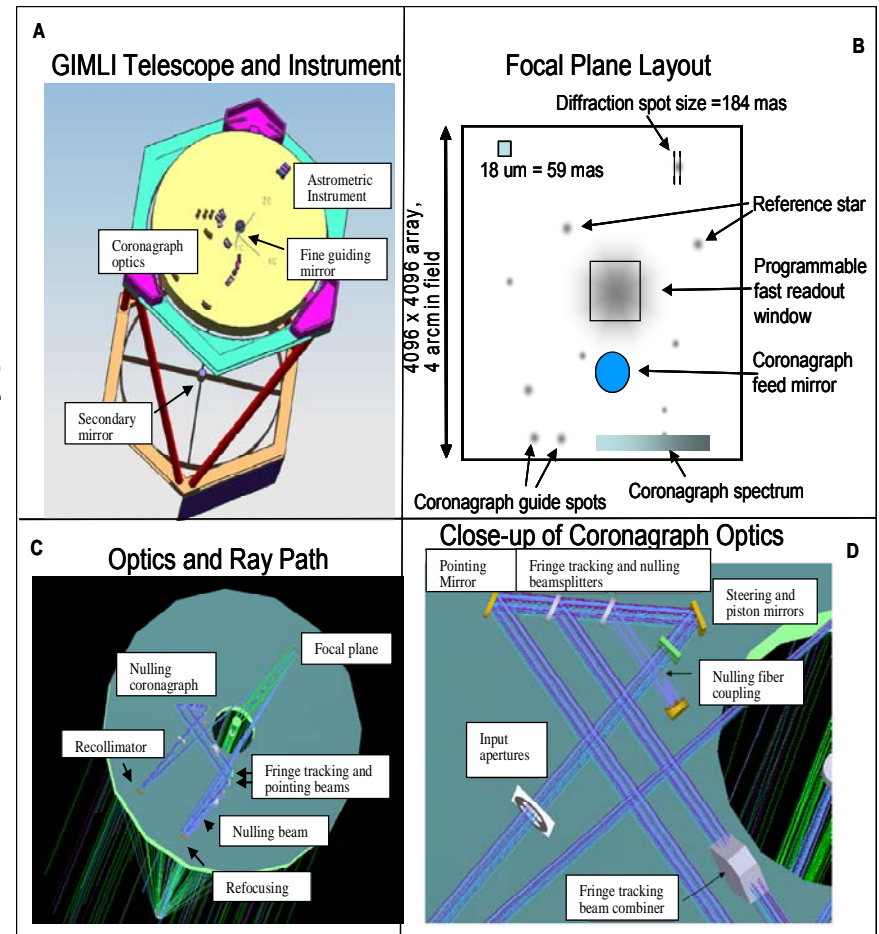
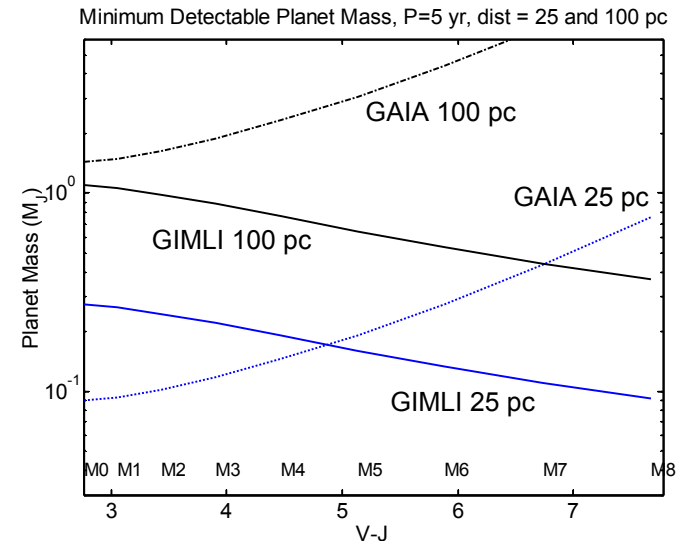


Figure 1-7: Telescope and instrument layouts.

# Astrometry: Smaller Space Missions 3

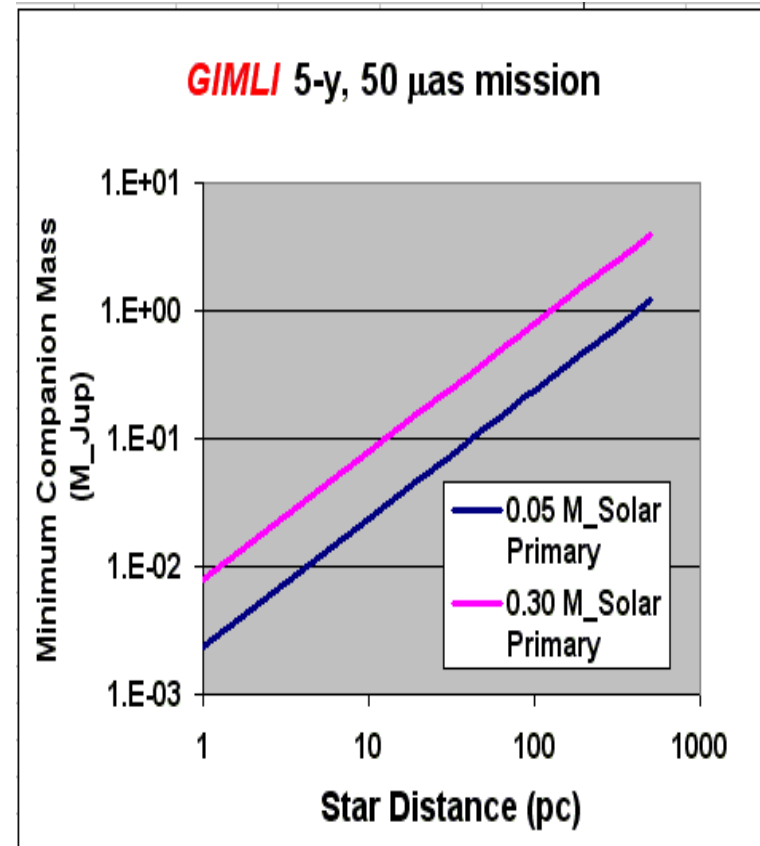
- **Why?**
  - Detect a significant number of planets around low-mass stars (complements GAIA)
  - Sample both older stars and young stars in star-formation regions



The detectable planet masses vs. star color with redness increasing and visible magnitude decreasing to the right. GAIA is photometrically limited over the range shown; minimum planet mass increases as the stars become fainter.

# Astrometry: Smaller Space Missions 4

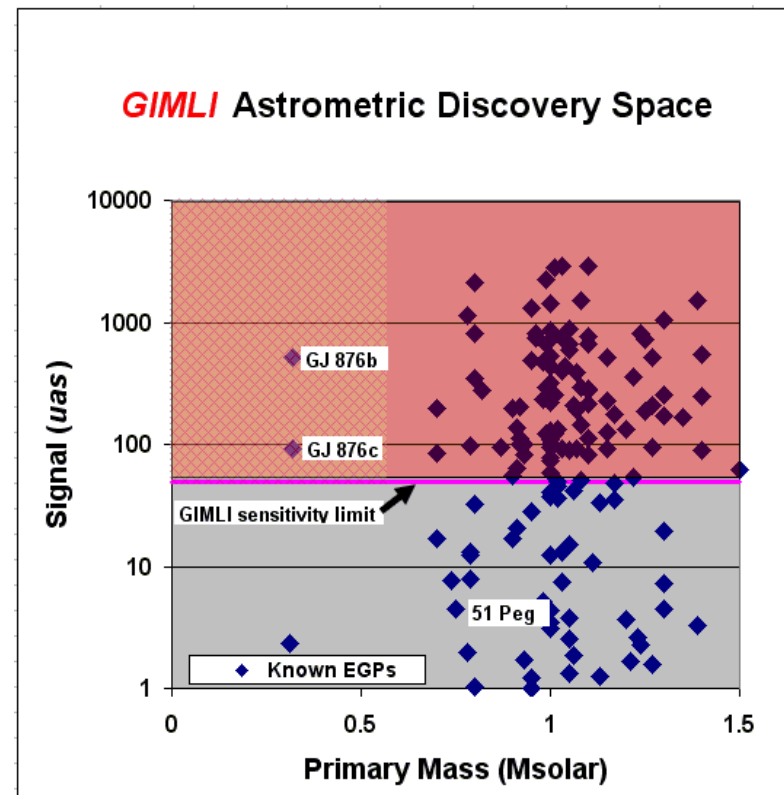
- Find planetary systems with EGP masses down to 0.01 Jupiter-mass as candidate systems for Earths and targets for Earth-finders



GIMLI will discover exoplanets down to masses < 0.01 Jupiters

# Astrometry: Smaller Space Missions 5

–Use the high dynamic-range imager (HDR) to measure masses of RV companions



GIMLI can observe all stars in colored region but will focus on hatched region, i.e., stars with less than 0.5 the Sun's mass, where few planets are known.